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ABSTRACT

In order to determine which kind of mathematics program would produce the best results for kindergarten children, three programs from different theoretical perspectives were developed. The first program, behavioristic in focus, made use of texts, worksheets, and seatwork. The second, cognitive-developmental in outlook, stressed conceptualization of numbers and number systems through manipulatives, games, puzzles, simulations, field trips, and the frequent use of three-dimensional objects. The third program, labeled "eclectic," included total group responses, high structure, and much repetition; activities included both textbook seatwork and some worksheets, along with games and simulations. A total of 96 children from six public kindergarten classes in three elementary schools in Fairbanks, Alaska, participated in the study. Children were pretested with the Metropolitan Readiness Test. The Comprehensive Test of Basic Skills, Level A, was administered as a posttest. Results revealed that the cognitive-developmental approach yielded significantly higher achievement in mathematics than either of the other approaches. The mean score for children in the behavioristic group was higher than that of the eclectic group, but the difference was not significant, nor were any sex-by-treatment interactions found. These results are considered remarkable in view of the fact that the children in the behavioristic program scored significantly higher before treatment and that twice as many adult instructors were present in this program as were present in either of the other two approaches. (Author/RH)

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Mathematics Achievement in Young Children Is Increased With A Cognitively Oriented Curriculum

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Abstract

A sample of 96 kindergarten children were divided into three groups. Each group, made up of a wide range of ability and socioeconomic levels, was taught material from a basic mathematics text and were administered the CTBS, Form A at the end of kindergarten. The three methods were behavioristic, cognitive-developmental and eclectic. The cognitive developmental approach yielded significantly higher achievement in mathematics than either of the other approaches. The mean score for the behavioristic group was higher than the eclectic but the difference was not significant. There was no sex x treatment interactions.

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Teachers want to do what is best for their students but often there is no definitive statement as to what is best. For instance, kindergarten mathematics programs for frequent combinations of various activities and techniques and there is little empirical evidence in the research literature as to what is clearly effective. The theoretical bases underlying the programs usually cannot be identified. Some programs stress drill in recitation of number names and facts while other focus on comprehension of number concepts through games, puzzles, blocks, etc. If both conceptualization and the learning of number facts are the objectives of mathematics, the theoretical approach to instruction is important. The more behavioristic approaches stress worksheets, drill, practice and more drill. Such programs teach the rote learning of number facts and the proponents of such programs believe that the comprehension will come later (Bereiter & Englemann, 1966). The cognitive developmental approach encourages the acquisition of mathematical concepts through informal instruction embedded in games, puzzles, field trips, social interactions, block play, and other cognitively-oriented activities. Instruction which

has both computation and concept learning as its goal might try to borrow from both the conceptual program and the drill program. The name for such an approach in this study is eclectic.

Questions Asked

In order to answer the question of which kind of mathematics program, if any, would produce the best results for kindergarten children, three programs from different theoretical perspectives were developed and the following questions were asked:

Would there be a significant difference in achievement scores in mathematics between the three groups?

Would there be significant differances by sex on achievement scores in mathematics between the three groups?

Since most of the research in the literature seemed to deal with disadvantaged children, (Lazar & Darlington, 1978) this study evaluates the programs' effectiveness in "regular" classrooms. Regular classrooms in this study refer to classes where the children come from homes of differing socioeconomic status, stability, father's occupation and ability. In other words regular classrooms are heterogeneously grouped children who have been randomly assigned to their particular classroom.

Three Types of Programs

The three programs were alike in the fact that they all were required to use the district adopted text as their basic core. They differed in that they came from different theoretical directions. The first was a

behavioristic program. This program used the text, worksheets, and seatwork. Every child worked through the same sequence of materials whether he needed to or not. The program was teacher directed to the total group. There was much drill and practice. Oral choral responses were frequent as were ditto sheets completed as seatwork. Such programs have been reported in the literature as having particular success with disadvantaged children.

The next program was a cognitive developmental program which stressed conceptualization of numbers and number systems through manipulatives, games, puzzles, simulations, field trips and the frequent use of three dimensional objects. A Piaget-oriented cognitive developmental curriculum was the model (Kamii, 1972, 1973, 1974). The major instruction was through learning center activities from which the child could choose alternative ways to learn a skill or concept. It was activity oriented rather than seatwork oriented. Students were organized for individual and small group activities. Developmental differences are recognized in the levels of activities in the centers. Informal opportunities were used to facilitate the children developing a knowledge of the properties of numbers. Social settings, field trips, and playgrounds were the site for some of these.

The third program was an attempt to achieve the best of two worlds. It might be called eclectic or pragmatic. There were total group responses, high structure and much repetition but the activities included both text-book seatwork and some worksheets along with games and simulations.

Sample

The sample consisted of 96 children in six public kindergarten classes in three elementary schools in Fairbanks, Alaska. Five teachers participated. Within each school children were randomly assigned to teachers and to morning or afternoon sessions. Knowledge of neighborhoods from which children were drawn and various occupations and education of parents, gave evidence of the heterogeneity of the sample.

Procedures

Originally 125 children were tested in the fall. Other children who had arrived during the year were tested in the spring. Any child for which there were not a pre and a post test were eliminated from the sample. Attrition was proportional across programs. In the fall the Metropolitan Readiness Test was given. The purpose of giving the MRT was to measure the readiness level of the three groups to see if the groups were comparable prior to treatment. In the spring the Comprehensive Test of Basic Skills (CTBS), Level A, was administered. The mathematics items on the CTBS are constructed from objectives which are compatible with the objectives of the school district and the publisher of the textbook adopted by the district. During the eight months which intervened between the two tests each of the three programs was taught as described. These three programs composed t... treatment, the independent variable in the study. Monitors visited the programs on an unannounced schedule to verify that each was conforming to its approach. During the second observation visit to the behavioristic

program, a trained aide was found to be part of the instructional staff. She had been absent on the first visit and the teacher had not mentioned her because she thought all teachers had aides. This changed the student-adult ratio for these sections over the other programs.

Results

When the Metropolitan Readiness Test (MRT) scores were compared, a significant difference in the scores of the children was found on the pre-test in favor of the children in the behavioristic program. Since all the students came from the same population, the MRT was used as a covariate in the analyses of variance of the posttest scores to partial out the differences that were present at the beginning.

The CTBS Mathematics score was the dependent variable in a two-way analysis of covariance (with the MRT as the covariate) by sex and program. Means for the MRT (pretest) and the CTBS (posttest) by program are found in Table 1.

Insert Table 1 about here

Significant differences were found between the three programs. (F 2,95 = 12.84, p < .001). The cognitive developmental program was

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Insert Table 2 about here

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significantly higher than either of the other two. At least square means

post hoc comparison revealed this difference. See Table 3.

Insert Table 3 about here

No sex differences were found.

Discussion

Each teacher believed that her method was the best to realize high achievement of her students. Although all teachers used the same basic text, the programs did not look alike in the classroom. All programs produced average or above average achievement but there were marked differences in them. The eclectic program which took promising practices from both the behavioristic and the cognitive developmental programs effected the least achievement, which was average compared with the national percentiles (50%ile). The mean score for the behavioristic program was above average (77%ile) and the mean score for the cognitive developmental program without any adjustment for initial differences between programs was at the 86 %ile, well above average. Considering that the children in the behavioristic program were significantly higher before treatment, and had twice as many adults instructing in the program, the results are all the more remarkable.

The program which coordinated games, puzzles, manipulatives and other action-oriented activities into the instruction was the most effective approach to facilitating children's development of an understanding of

number in regular classes of kindergarten children. This program was modelled after Piaget based cognitive developmental programs and encouraged intense student interaction with the physical and social environment. Piaget's concern for children's opportunities for reflective abstraction was a major consideration in the development of this program. Much of the mathematics instruction was embedded informally in other curriculum activities. Exploration, experimentation, choice making and other child centered activities offered many opportunities for the development of mathematical concepts. Findings concerning the distancing hypothesis as proposed by Sigel (1968) were also taken into account. As many "hands-on" activities as possible were incorporated into the curriculum. The results of this study would seem to support Piaget's theory that children can conceptualize better with three dimensional objects rather than two dimensional representations.

Because sex differences have been found in mathematics in the upper grades, (Maccoby & Jacklin, 1974) it is reassuring to know that those differences did not exist in kindergarten in this study.

Although results of this study are clear for the population from which the sample was drawn, caution should be exercised in generalizing to other locales, samples homogeneously grouped by SES, or populations which differ from the group studied.

Table 1

Means and Standard Deviations of Students

On MRT (Pretest) and CTBS (Posttest) by Program

	Pgm 1 (Behavioristic)	Pgm 2 (Eclectic)	Pgm 3 (Cog. Dev.)
Metropolitan Readiness (Pretest)	136.00 (26.36)	108.19 (25.34)	118.59 (23.39)
CTBS Mathematics (Posttest)	235.50 (15.28)	215.67 (31.25)	246.25 (26.58)

Table 2

Two Way Analyses of Covariance with MRT as

Covariate for Posttest CTBS by Sex and Program

	df	Sum of Squares	Mean Sum of Squares	F	P
CTBS (Posttest)					
Mathematics					
MRT	1	27865.22	27865.22	62.81	.0001***
Sex	1	26.22	26.22	.06	.81
Program	2	11390.47	5695.24	12.84	.0001***
Sex * Program	2	62.67	31.34	.07	.93
Error	89	39481.38			
Total	95	78825.96			

*** $p < .001$

Table 3

Least Square Means Table for

Post Hoc Comparison of Groups on

CTBS Mathematics Skills

Pgm	LS Mean	Std Error LS Mean	p Values Pgm 1 Beh	Pgm 2 Ecl	Pgm 3 Cog
1 Beh.	225.26	4.27		.69	.0002***
2 Ecl.	222.93	3.69	.69		.0001***
3 Cog.	247.41	3.85	.0002***	.0001***	

*** p < .001

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